Chapter 1

Introduction

1.1 Introduction to Athletics

Athletics is one of the oldest and most universal sports, with its roots deeply embedded in human history. The term athletics originates from the Greek word athlos, meaning “competition,” which highlights the essence of striving for excellence through physical performance. Evidence of organized athletics can be traced back to ancient Greece, where the first Olympic Games were held in 776 BC at Olympia, featuring running, jumping, and throwing as the core events. Over centuries, athletics evolved into a structured, regulated, and globally recognized sport that continues to be one of the most important disciplines in the Olympic Games. The Olympic motto “Citius, Altius, Fortius”—translated as “Faster, Higher, Stronger”—epitomizes the very spirit of athletics, symbolizing the human pursuit of breaking barriers in speed, strength, and endurance. Athletics is widely regarded as the “mother of all sports” because it consists of natural human movements such as running, walking, jumping, and throwing, which not only form the foundation of athletics itself but also serve as the basis for most other sports. These movements are fundamental to physical education, grassroots training, and general fitness programs worldwide, making athletics not only a competitive activity but also a vital contributor to overall human development and health. Athletics events are broadly divided into two major categories, track events and field events, each testing unique physical and motor qualities. Track events include sprints, middle- and long-distance races, hurdles, and relays. These contests emphasize speed, rhythm, endurance, agility, and tactical precision, reflecting the principle of “Citius” or faster. Athletes are ranked based on their race times, which underlines the critical importance of velocity and efficiency in track disciplines. On the other hand, field events represent the principles of “Altius” and “Fortius” or higher and stronger, through disciplines such as the long jump, triple jump, high jump, pole vault, shot put, discus throw, javelin throw, and hammer throw. Success in these events depends on explosive strength, refined technique, body coordination, and physical power. Thus, athletics as a whole encompasses a balanced combination of speed,

power, endurance, flexibility, and skill, making it one of the most comprehensive sports known to mankind. The global governance of athletics lies with World Athletics, formerly known as the International Association of Athletics Federations (IAAF), established in 1912. This governing body is responsible for setting standardized rules, ensuring fairness, and promoting athletics worldwide. World Athletics oversees not only traditional track and field events but also a wide variety of additional disciplines such as road running, race walking, cross-country running, mountain running, ultra-running, and combined events like the decathlon and heptathlon, which test all-round athletic ability. This broad spectrum of competitions demonstrates the inclusivity and adaptability of athletics, allowing athletes with different strengths and skills to participate at multiple levels. Athletics holds great importance not only as a competitive sport but also as a means of promoting fitness, discipline, perseverance, and fair play. The sport is highly accessible since it requires minimal equipment and infrastructure, which is why it is practiced extensively in schools, colleges, and communities around the world. Athletics also plays a major role in fostering national pride, as performances on the Olympic and World Championship stage inspire millions and symbolize achievement for entire nations. Legendary athletes such as Jesse Owens, Carl Lewis, Usain Bolt, and Florence Griffith-Joyner have transcended sport to become global icons, further highlighting the cultural and inspirational value of athletics. In the modern era, athletics has been shaped by scientific and technological advancements, making it not just a physical contest but also a field of applied science. Biomechanics helps optimize technique in running, jumping, and throwing, while sports physiology explains energy systems, muscle fiber recruitment, and recovery processes that support performance. Nutrition and sports medicine ensure that athletes remain healthy, while sports psychology focuses on motivation, focus, and mental resilience during competition. Technological innovations such as motion analysis, digital timing, advanced footwear, and recovery equipment continue to push performance to new levels. Despite these modern advancements, the simplicity of athletics—running faster, jumping higher, and throwing farther—remains its greatest charm, as it directly represents the limits of human ability.

• Sprinting Events

Sprinting events, which include the 100 meters, 200 meters, and 400 meters, are regarded as some of the most explosive and demanding competitions in track and field athletics. These short-distance races usually last between 9 and 50 seconds, providing athletes with only a brief moment to showcase their speed, strength, and technical ability. With such little room for mistakes, even the slightest lapse in focus, stride, or timing can determine the outcome. The honor of being titled "The World's Fastest Runner" gives these races a unique charm and prestige. Without question, sprint events form the centerpiece of athletics competitions, known for their intensity, short duration, and the extreme physical challenges involved in pushing the human body to its highest limits. To succeed, sprinters must maintain outstanding levels of overall fitness, combining speed, agility, coordination, power, and endurance. Alongside conventional resistance training techniques, plyometric training has gained attention as an effective method for developing explosive strength and improving athletic performance.

• Plyometrics

Plyometric training, often referred to simply as *plyometrics*, is a specialized method of exercise designed to improve muscular power by rapidly shifting from muscle stretching to contraction through explosive movements. The primary aim of this training is to enhance the muscles' ability to generate maximum force in minimal time, thereby improving the crucial combination of strength and speed needed for optimal athletic performance.These exercises replicate the fast and powerful movements required in sprinting, which makes plyometrics especially valuable for sprinters striving to elevate their performance levels. The impact of plyometric training on sprinting efficiency was highlighted in the 1970s, when Soviet athletes showcased remarkable results. Sprinters such as Valeriy Borzov benefited from the groundbreaking *Shock Method* introduced by Dr. Yuri Verkhoshansky, who is widely recognized as the pioneer of plyometric training.

1.1 Statement of the problem

Plyometric training has been a cornerstone of athletics, with the Soviet Union using it extensively and effectively. Over the years, many athletes around the world have attested to its benefits. Despite being the second-largest population in the world, India has struggled to establish a strong presence in global sports. One of the main reasons for this is the lack of proper research and the application of scientific methods in athletic training. Often, training programs are unorganized and lack a clear structure. To truly nurture world-class athletes, there is a need for a more planned, structured, and scientific approach to training. Very few studies have looked at how plyometric training impacts Indian athletes specifically. This highlights the need for research that measures the performance of athletes when plyometric training is added to their existing routines. To fill this gap, an experimental study will be conducted to explore the potential benefits of incorporating plyometric exercises into training programs.

1.2 Significance of the study

The following are some ways that the study is advance understanding.

- The study is analyzed the importance of selected motor fitness on improving the performance of selected sprinters.
- The study is helping sprinters to improve speed
- The study is helping sprinters to increase Explosive Strength
- The study is helping sprinters to improve reaction time,
- The study is helping sprinters to improve flexibility
- The study is helping sprinters to increase muscular endurance
- This study examines the effects of plyometric training on improving specific motor fitness components and sprinters' skill performance.

Understanding the effects of plyometric on the above-mentioned factors, are help design a training programmer that can be implemented to improve the performances of athletes of sprint events.

1.3 Objectives of the study

The primary goal of the study is to determine how plyometric training affects certain motor fitness traits like speed, muscular endurance, Flexibility, and response time, as well as the skill performance of collegiate sprinters. The specific objectives are:

To identify the plyometric exercises that help to improve performance of sprinters in 100m event and design a suitable coaching plan

1. To investigate how plyometric training affects collegiate male sprinters' speed
2. To investigate how plyometric training affects collegiate male sprinters' explosive strength
3. To investigate how plyometric training affects male collegiate sprinters' reaction times
4. To investigate how plyometric exercise affects collegiate male sprinters' flexibility
5. To investigate how plyometric exercise affects collegiate male sprinters' muscle endurance
6. To investigate how plyometric training affects collegiate men sprinters' skill performance

1.4 Research problem

Plyometric training has historically been extensively utilized and proven effective in athletics, notably by the Soviet Union. Athletes worldwide have consistently attested to its benefits. Despite India's standing as the world's second most populous country, it has yet to establish a dominant presence in sports. The primary hindrance lies in the lack of comprehensive research and application of scientific techniques in athletics training. Many training programs in India are conducted without proper structure or planning, highlighting the critical need for a systematic and scientifically grounded approach to nurture athletes. There remains a notable scarcity of studies examining the impacts and feasibility of plyometric training specifically tailored to Indian athletes. Therefore, there is an urgent requirement to conduct research that assesses the performance outcomes of athletes following the integration of plyometric training into their existing regimens. To address this gap, an experimental study will be undertaken

with the aim of investigating this topic thoroughly. Top of Form Bottom of Form "Effect of Plyometric Training on Selected Motor Fitness Components and Skill Performance of College Male 100 meter Sprinters in Mumbai".

1.5 Hypotheses

The following hypotheses are presented.

H1: Plyometric training significantly increases the speed of male collegiate sprinters.

H2: Plyometric training significantly increases the Explosive Strength of male collegiate sprinters. H3: Plyometric training significantly improves the response time of male collegiate sprinters.

H4: Plyometric training significantly increases the flexibility of male collegiate sprinters.

H5: Plyometric training significantly increases the muscular endurance of male collegiate sprinters.

H6: Plyometric training significantly increases the Skills performance of male collegiate sprinters.

1.6 Limitations

Uncontrollable factors associated with the study were accepted as limitations and the following were considered as limitations of the research study.

- Certain factors like life style, daily routine work and diet may have impact to certain extent on the effect of the results of the present study, however since these factors were considered as uncontrollable, they turn to be limiting factor in the present study.
- The atmospheric temperatures which were not taken into account while collecting data was considered as a limitation to the study.
- The food habits of the subjects which may affect the result were considered as a limitation to the study.
- Acquisitions of new skills during the session for higher performance were considered as a limitation to the study.

- It was not possible to control the day-to-day activities of the subjects selected for experimental groups which included diet, food habits, rest and practice session and duration.

1.7 Delimitations

The study was delimited to college male 100m sprinters.

- The subjects for the study were delimited to the age group between 18 to 25 years college male 100m sprinters, from Vidyalankar College.
- The plyometric training was delimited to 12 weeks; alternate days in a week of one and half hour's duration in the morning session.
- The variables were delimited to selected motor fitness components of speed, explosive strength, reaction time, flexibility, muscular endurance and skill performance of college male 100m sprinters.

1.8 Operational Definition of Terms and Concepts

- ❖ Sprinters: A sprinter is an athlete who runs a short distance (100m,200m or 400m) at top speed.
- ❖ Plyometrics: Plyometrics are exercises in which muscles exert maximum force in short intervals of time with the goal of increasing power.
- ❖ Motor Fitness Components: Motor fitness components are the basic characteristics of muscles that are associated with muscle activity.
- ❖ Skills of Sprinters: A sprinter should possess skills to start the race immediately, reach maximum speed in shortest time and maintain the maximum speed.

Chapter 2

Review of Related Literature

Khilna, Vijaykumar, and Sahana (2021) carried out a review study to val.idate yoga modules tailored for volleyball players. Volleyball, known for its dynamic nature and team-based gameplay, demands both strong physical and psychological attributes from its players, with overuse injuries being common. The study aimed to assess yoga as a therapeutic, rehabilitative, and preventive approach that is non-invasive, non-pharmacological, and cost-effective. The researchers created a customized yoga protocol by reviewing classical yoga texts and existing research.

Mohamed Azeez and Balamurugan (2021) examined the impact of game-specific plyometric training on the strength endurance and explosive power of male volleyball players. During the 2019–2020 academic year, twenty male volleyball players from various departments at Annamalai University in Chidambaram, Tamil Nadu, took part in the study. The participants, who were between the ages of 18 and 23, were randomly assigned to one of two groups: the experimental group or the control group. Ten people participated in each group. Sit-ups and vertical leaps were used to test the subjects' strength endurance and explosive power before and throughout the training session, respectively. For six weeks, the experimental group received game-specific plyometric training while the control group did not the results, which were analyzed with ANCOVA, showed a significant rise in the experimental group's strength endurance and explosive power.

Sankarmani et al. (2012) compared the effects of weight training with and without plyometric workouts in an investigation. Forty collegiate athletes participated in the study and were split into two training groups at random: one group trained with plyometric weights while the other group just used weights. A 6-week training course was finished by both groups. The findings showed that compared to athletes who solely participated in weight training, those in the plyometric weight training group showed more notable gains in

anaerobic power and muscle strength. In particular, the plyometric weight training group showed significant improvements in one-repetition maximum (1RM) squat performance, 50-yard dash speeds, and vertical jump height. The study concluded that increasing vertical leap is more successful when plyometric workouts and weight training are combined.

Mandeep Singh et al. (2012) explored the impact of plyometric training, resistance training, and their combination on the flexibility of state-level adolescent male athletes. The study targeted athletes aged 13 to 18 years from schools in Ambala city, all of whom had competed at the state level in athletics. With 66 subjects per group, the participants were separated into three groups: a control group, an experimental group 1 (plyometric training), and an experimental group 2 (resistance training). Wooden boxes of different sizes, medicine balls, and skipping ropes were among the tools used in plyometric training. Resistance training used rubber plates with varying weights, barbells, matting for sit-ups, an adjustable equipment for bench presses, and a fixed bar for pull-ups. For the study, the reliability and accuracy of these instruments were validated. To determine the statistical implication of differences between the group means, the researchers used Analysis of Covariance (ANCOVA). The Least Significant Difference (LSD) Test was also applied to assess significant improvements. The hypothesis was tested at a 0.05 level of significance. The findings revealed that "plyometric training" was superior to both resistance training and the combination of the two in enhancing the flexibility of the athletes.

Indranil Manna et al. (2012) aimed to assess the impact of training on the "anthropometric, physiological, and biochemical" variables of Indian male volleyball players under 19 years of age. The study involved 30 male volleyball players, aged 16 to18.99 years (average age: 17.7 ± 0.5 years), who were actively engaged in competitive volleyball. The training regimen was structured into two phases: 8 weeks make up the Preparatory Phase (PP), while 4 weeks make up the Competitive Phase(CP). Training sessions lasted four hours a day, five days a week, and included both aerobic and anaerobic activities as well as skill development. At the beginning (baseline data, BD), following the PP, and at the end of the CP, measurements were made for a number of variables. Important results showed notable gains ($P<0.05$) in: "Anaerobic energy, strength of the back and grasp, Urea in serum, HDL-

C, or high-density lipoprotein cholesterol", Additionally, there were notable decreases ($P<0.05$) in the following: "hemoglobin levels, recovery heart rate, body fat percentage, levels of triglycerides, LDL- C, or low-density lipoprotein, cholesterol, Temperature, body mass, lean body mass (LBM), maximum heart rate (HRmax), and maximum oxygen uptake (VO2max)" did not alter significantly. uric acid, Levels of total cholesterol. These results can assist coaches in evaluating the current fitness and training adaptability of athletes, enabling them to adjust training programs to achieve optimal performance.

Parastoo Ossanloo, Najar, and Zafari (2012) investigated the effects of combination training, which comprised step exercises, strength training, and aerobic dancing, on the "lipid profiles and body fat percentage" of inactive females at AL-ZAHRA University. The aim of this study was to address the paucity of information on how different forms of exercise and their combinations affect blood lipid profiles and body fat. The study includes further to assess how a 12-week combined training program affected the body fat percentage and serum lipid profiles of girls who were not exercising. Out of 100 participants, 80 inactive females between the ages of 25 and 45 were chosen at random using the Physical Activity Rating Questionnaire and American College of Sports Medicine criteria.

Moises et al. (2021) assessed the impact of two distinct resistance training (RT) programs over a period of 15 weeks, with sessions held twice a week, on various physical performance metrics in young male soccer players. A control group and an exercise group of 40 people were randomly selected from among the participants. The workout improvements in "aerobic endurance (VO2 max), lean mass, body mass, height, and body fat % were the main goals of the study, which contrasted an overload group (OG) with a self-load group (SG)". The average age of the OG was 16.28 ± 1.21 years, whereas the average age of the SG was 15.34 ± 1.34 years. Participants were randomized at random to either the OG or the SG. The significance level for the study was set at $p \leq 0.05$. Results showed that both RT methods led to significant improvements in the measured variables.

Rangaraj & Jesus Rajkumar (2020) investigated how resistance and plyometric training affect agility in intercollegiate male hockey players. The research comprised 45 male hockey players, ages 18 to 21, from different colleges affiliated with the University of Madras in Tamil Nadu. Three groups of fifteen individuals each were formed from the participants: two experimental groups and one control group. Before starting the training, agility was assessed with a pre-test. The Control Group carried on with their regular activities without any extra training, whereas Experimental Group I and Experimental Group II got resistance and plyometric exercise, respectively. Over the course of 12 weeks, both experimental groups engaged in their respective training regimens. Shortly after this time, a post-test was administered. “ANCOVA and Scheffe's” post hoc test was employed to examine the findings. According to the results, strength training significantly increased agility more than plyometric training or the control group. Determined that strength training significantly improved agility more than plyometric training and the control group. According to the study, of the training techniques examined, resistance training was the most effective for improving agility in intercollegiate male hockey players. This suggests that incorporating resistance exercises into training programs may be particularly beneficial for developing agility in athletes.

Selvapandian & Arumugam (2019) examined how male hockey players' shoulder and core strength was affected by TheraBand resistance training. Twenty individuals, ages 21 to 25, from Woodenware College in Salem, which is connected to Paraiyar University in Tamil Nadu, India, participated in the study. Participants were divided into two groups at random: Group I (n = 10) went through resistance training with TheraBand, and Group II (n = 10) was the control group. Over the course of six weeks, Group I received resistance training with TheraBand four days a week, lasting 45 to an hour per session. Group II did not receive any particular training intervention; they carried on with their usual routines. Push- up and plank tests were used to evaluate shoulder and core strength, respectively. Data from the pre- and post-tests for core and shoulder strength were considerable gains in core and shoulder strength. However, there were no appreciable changes in these variables in the control group. This suggests that whereas the control group did not gain from their usual activities alone, hockey players' shoulder and core strength can be improved with Thera

band resistance training. determined that male hockey players' shoulder and core strength was considerably increased by Thera band resistance training. While the control group, which did not take any training, did not show any significant gains in shoulder and core strength, those who participated in the Thera band resistance training had noteworthy improvements in these areas. This demonstrates how well Thera band resistance training works to build important physical characteristics for hockey players.

Yildirim et al. (2018) examined the effects of a multi-week plyometric training programon physiological parameters and freestyle swimming performance in 10-11-year-old male swimmers from Van. In this study, 24 volunteer swimmers who practiced five days a week were split between two groups at random: a test group and a control group, each consisting of 12 athletes. Along with their normal swimming workouts, the test group participated in a three-day-per-week plyometric training program, whereas the control group carried on with their regular swimming training regimen without any extra exercises. When data analysis showed that the findings did not fit a “normal distribution, non-parametric tests—the Wilcoxon and Mann-Whitney U tests”, in particular—were employed. The results demonstrated that plyometric training considerably enhanced vertical leap ability. Even though the test group's gains in freestyle swimming time were not statistically significant, the findings point to a beneficial impact of plyometric training on swimming.

Dr. Carlo Bosco (1988) The connection phase, often referred to as the transmission or amortization phase, is an essential part of a plyometric workout. To fully benefit from the Stretch Shortening Cycle (SSC), it is essential. This stage is in between the exercise's eccentric (loading) and concentric (unloading) stages. It must be swift and seamless to go from muscle lengthening to muscle shortening during the coupling phase. Delays or disruptions in this transition may cause the muscles' elastic energy, which was saved during the loading phase, to be released as heat instead of being used for the explosive action. This energy dissipation reduces the effectiveness of the plyometric exercise. For optimal results, the coupling phase needs to be as brief as possible. Any delay or discontinuity during this phase can prevent the exercise from fully utilizing the SSC, thus diminishing its plyometric benefits. In essence, the efficiency of the coupling phase directly impacts the overall effectiveness of the

exercise. Ensuring a rapid and continuous transition helps maximize the force and power generated during the plyometric movement.

Dr. Yuri Verkhoshansky's1996 - on plyometric training includes detailed insights into the unloading phase. According to him, this phase is the release of the elastic energy that was accumulated during the eccentric (loading) phase. Rapid muscular shortening is necessary to provide explosive power during this period of performance. According to Verkhoshansky, optimizing the advantages of plyometric workouts and improving general strength and power require a seamless, rapid transition from the loading to the unloading phase. Willison: Shortening the stretched muscular tendon unit is the unloading phase of a plyometric workout, which comes just after the coupling period. The unloading phase of lower extremity activities starts when the muscular tendon unit starts to shorten and finishes until the toes are off [3]. Because of the processes triggered during the loading phase, this phase is referred to as the payout or outcome phase. This stored energy is then returned during the latter part of the stance phase. The tendons act like springs, releasing the stored energy in a spring-like manner, which enhances the efficiency of movement. This elastic recoil mechanism reduces the energy cost of locomotion and improves overall performance by aiding in the propulsion of the body. By studying these mechanical and energetic aspects of tendon function, researchers can better understand how tendinous tissues contribute to effective and efficient locomotion.4o mini

Prue Carmie (2018) reviewed many research on maximizing neuromuscular function in sport performances and the ability of an athlete to generate maximal muscular power. The review indicated that an athlete's capacity to create maximal muscular power is impacted by their strength. As a result, while contemplating long-term power growth, it is critical to improve and sustain maximum strength. Traditional resistance training techniques with large weights can help to develop strength. Power training is required to transfer the effect from training to performance. The researcher suggested ballistic, plyometric and weightlifting exercises for power training. As plyometric exercises mimic the loads similar to those encountered in particular sports, it is chosen as the main component for training athletes under study. Plyometric training entails workouts in which muscles provide maximal force in brief bursts. It concentrated on quickly and explosively transitioning from

muscular extension to contraction. Maximal power generation during difficult motor skills is critical for optimal sports performance.

Wagner and Kocak (1997) After six weeks of plyometric exercise, the anaerobic power of 20 athletes, 20 non-athletes, and 20 controls was assessed using a multivariate technique. The vertical leap, 50-meter sprint, and Margaria-Kalamen stairclimbing test pre- and posttest results were analyzed using a 3×2 mixed model MANOVA. Plyometric training resulted in significant gains ($p < 0.01$) in all measures of anaerobic power for both athletes and non- athletes, according to the significant group-test interaction ($p < 0.001$). The Margaria- Kalamen stairclimbing test was the most successful in measuring anaerobic power gains among the tests, indicating that it is a better evaluation method than the 50-meter sprint or vertical leap. Plyometric exercise is advantageous for improving lower body strength, according to the study's findings.

Wasim Khan et al. (2020) University students' speed, leg explosive power, and muscle endurance were evaluated in relation to different plyometric exercise intensities. A Control Group (CG, $n = 15$) and an Experimental Group (EG, $n = 45$) comprised the two major groups of sixty participants, whose average age was 21.37 ± 1.40. Based on the level of plyometric exercise intensity, the EG was further divided into three subgroups: Low, Medium, and High-Intensity. The analysis of covariance used in the study has a significance threshold of $p < 0.05$. Plyometric training significantly increased the experimental groups' speed, leg explosive power, and muscle endurance over the course of eight weeks ($p < 0.05$). When it came to improving key motor skills, high-intensity plyometric exercise outperformed the other training intensities.

YC Wang (2016) Soccer players' reactions to plyometric preparing were inspected. It was found that owing to the numerous nature of soccer's physical needs, which incorporate quality, perseverance, control, and dexterity, preparing must address these components comprehensively. Plyometric preparing illustrates an extraordinary capacity to exchange and progress particular cardiovascular and neuromuscular fitness. Plyometric preparing moves forward VO2 max, maximal quality, sprinting speed,

strong kick, continuance, deftness, specific football player abilities, and vertical jump capacity in men and ladies of all ages, counting recreational and proficient competitors.Moreover, preferences incorporate strong and ligament reinforcing, which makes strides the capacity to maintain a strategic distance from wounds. As a result, it was suggested that plyometric movement be consolidated into football player preparing schedules, as it is in numerous other sports. Security viewpoints must be tended to, which incorporate assessing the competitor, guaranteeing the security of offices and hardware, setting up sport-specific objectives, selecting program plan components, instructing the competitor legitimate procedure, and viably promoting the program.

Chapter 3

Methodology

3.1 Methodology

This quantitative study employed a true experimental design to examine the effect of plyometric training on motor fitness and sprint performance. Athletes were divided into experimental (EG, n=75) and control (CG, n=75) groups Both students' groups received from Vidyalankar college and Researcher scholar was selected randomly for 12 weeks while the EG additionally performed plyometric exercises (30–45 minutes, 3 sessions in a week).

- **Subjects**

The sample consisted of intercollegiate sprinters (100m) aged 18–25 years, selected using stratified probability sampling. This ensured representation across Both samples' groups received from Vidyalankar college and Researcher scholar was selected randomly for 12 weeks athletes.

- **Data Collection**

Pre- and post-tests on motor fitness components and sprint performance were conducted at Vidyalankar College, Wadala under standardized procedures. Athletes received warm-up, stretching, and demonstration prior to testing. Each subject performed three trials, with the best trial considered.

- **Training Design**

The 12-week plyometric program progressively increased intensity and surface hardness (grass, sand, plyo boxes, hurdles). Safety was ensured through proper footwear, quality equipment, and supervised sessions.

- **Statistical Analysis**

Data were analyzed using paired z-tests (within-group) and unpaired z-tests (between groups). A 0.05 significance level was used to test statistical differences.

3.2 Warm-Up

A fundamental principle of exercise is to warm up before beginning any training to prevent injuries. Warming up is crucial for preparing the muscles and joints for more strenuous activities. The warm-up routine aims to exercise all major joints, ensuring that the muscles are relaxed and stretched. A proper warm-up also enhances blood flow, increases muscle elasticity, and reduces the risk of injury. Following the warm-up, specific exercises can be performed to further target and strengthen the muscles involved in the training regimen.

Time distribution of the training session

Activity	Duration
Dynamic stretching General warming up (head to toes) Dynamic warming up	30min
Plyometric training	45min
Cooling down (relaxation)	15min

Dynamic Stretching Exercises

Dynamic Stretching Exercise (10 min)	Repetition	Distance	Recovery
Walk on toes Walk on heel,March pass walk Dorsey flex Cross march walk,Front rise leg Single leg deadlift Knee to chest Grainer Walking squat Great stretch alive Hamstring small step walk Glute/hip Inchworms Swing leg Partner shoulder stretch	10	10mtrs	Walk back to starting point

Dynamic Warm Up Exercises

Dynamic Warm Up Exercise (20 min)	Repetition	Distance	Recovery
Ankle drills Horse Tapping Butt Kickers Medium-high knee. High knee running Foreleg extension, straight leg jogging. High knee bounce, skip (bound). Ankle bounce. Long bounding High knee skip (Hanuman leap). Skip - A, B	1 Rep.	20mtrs	Walk back to starting point

3.3 Selection of Variables

3.3.1 Independent Variables

The independents variables were Plyometric training. activities three times a week, on Tuesday, Thursday, and Saturday.for 12 weeks. Researcher Scholar Used Equipment's like Grass Ground, Hurdles, plyometric box, cone, step up, ladder, In this research, the scholar selected a set of plyometric drills and implemented them in a 12-week training program for college-level sprinters. The training sessions were conducted three times a week on Tuesday, Thursday, and Saturday. Each session included specific drills with fixed sets, repetitions, duration, and recovery periods. The training followed a progressive approach, beginning with simple jumping drills in the initial weeks and moving towards more advanced bounding, hurdle jumps, and medicine ball throws in later weeks. Each drill was demonstrated step by step to ensure correct technique, while recovery time was given between sets to maintain performance and reduce fatigue. The overall program lasted for 12weeks, helping athletes improve speed, explosive Strength, Muscular endurance, flexibility, reaction time and skill performance in a safe and structured manner.

Plyometric Training Plan

Week 1

Days	Plyometric Drills	Sets	Repetition	Duration	Recovery	Total duration
Tuesday	Surface : Grass ground			2min	3min	5min.
	Vertical Depth Jump	3	15			
	Pin Jump	3	15			
	Squat Jump	3	15			
	Lateral Jump	3	15			
	Leg Bound	3	15			
	Back Jump	3	15			
	Over Head Throw	3	10			
	Over Back Toss	3	10			

	Surface: Soft Plyometric Box					

	Single Leg Jump	3	15			
	Double Leg Jump	3	15			
	Drop Single Jump	3	15			
Thursday	Double Leg Drop Jump	3	15	2min	3min	5min.
	Up And Down Jump	3	15			
	Tuck Jump	3	15			
	Explosive Start Throw	3	10			
	Side Throw	3	10			

Saturday	Step-Up			2min	3min	5min.
	Plyometric Push-Up	3	15			
	Split Jump	3	15			
	Scoop Hopping	3	15			
	Step Up-1	3	15			
	Step Up-2	3	15			
	Step Up-3	3	15			
	Step Up Clap Push Up	3	10			
	Wheel Barrow Walk Push Jump	3	10			

Week 2

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Surface : Grass Ground			2min	3min	5min.
	Cone/Ladder					
	Side to Side Ankle Hop	3	15			
	Front cone Hop	3	15			
	Lateral Jump Over Barrier	3	15			
	Bounding Over Ladder	3	15			
	Back Jump Over The Cone	3	15			
	Hop Over The Cone	3	15			
	Ladder Push Up	3	10			
	Ladder Walk	3	10			

	Surface : Sand					

Thursday	Sbj Single Jump	3	15	2min	3min	5min.
	Sbj Double	3	15			
	Sbj Tripple	3	15			
	Sbj Hop Single	3	15			
	Sbj Hop Double	3	15			
	Sbj Hop Triple	3	15			
	Over Head Throw	3	10			
	Over Back Toss	3	10			

Saturday	Hurdles Jump			2min	3min	5min.
	Front Bound	3	15			
	Side Bounding	3	15			
	Skip Bounding	3	15			
	Lateral Single Leg Jump With Bounding	3	15			
	Swimming Jump Under The Hurdles	3	15			
	Both Leg Jump Over The Hurdles	3	15			
	Explosive Start Throw	3	10			
	Side Throw	3	10			

Week 3

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Surface : Ground			2min	2min	4min.
	Vertical Depth Jump	3	10			
	Pin Jump	3	10			
	Squat Jump	3	10			
	Lateral Jump	3	10			
	Leg Bound	3	10			
	Back Jump	3	10			
	Over Head Throw	3	10			
	Over Back Toss	3	10			

	Surface : Soft Plyometric Box			2min	2min	min.
	Single Leg Jump	3	10			
	Double Leg Jump	3	10			
	Drop Single Jump	3	10			

Thursday	Double Leg Drop Jump	3	10			
	Up And Down Jump	3	10			
	Tuck Jump	3	10			
	Explosive Start Throw	3	10			
	Side Throw	3	10			

Saturday	Step-Up			2min	2min	4min.
	Plyometric Push-Up	3	10			
	Split Jump	3	10			
	Scoop Hopping	3	10			
	Step Up-1	3	10			
	Step Up-2	3	10			
	Step Up-3	3	10			
	Step Up Clap Push Up	3	10			
	Wheel Barrow Walk Push Jump	3	10			

Week 4

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Cone/Ladder			2min	2min	4min.
	Side To Side Ankle Hop	3	10			
	Front Cone Hop	3	10			
	Lateral Jump Over Barrier	3	10			
	Bounding Over Ladder	3	10			
	Back Jump Over The Cone	3	10			
	Hop Over The Cone	3	10			
	Ladder Push Up	3	10			
	Ladder Walk	3	10			

Thursday	Surface : Sand			2min	2min	4min.
	Standing Broad Jump Single Jump	3	10			
	Standing Broad Jump Double	3	10			
	Standing Broad Jump Triple	3	10			
	Standing Broad Jump Hop Single	3	10			
	Standing Broad Jump Hop Double	3	10			
	Standing Broad Jump Hop Triple	3	10			
	Over Head Throw	3	10			

	Over Back Toss	3	10			

Saturday	Hurdles Jump			2min	2min	4min.
	Front Bound	3	10			
	Side Bounding	3	10			
	Skip Bounding	3	10			
	Lateral Single Leg Jump (Bounding)	3	10			
	Swimming Jump Under The Hurdles	3	10			
	Both Leg Jump Over The Hurdles	3	10			
	Explosive Start Throw	3	10			
	Side Throw	3	10			

Week 5

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Surface : Ground			2min	2min	4min.
	Vertical Depth Jump	3	8			
	Pin Jump	3	8			
	Squat Jump	3	8			
	Lateral Jump	3	8			
	Leg Bound	3	8			
	Back Jump	3	8			
	Over Head Throw	3	8			
	Over Back Toss	3	8			

Thursday	Surface : Soft Plyometric Box			2min	2min	4min.
	Single Leg Jump	3	8			
	Double Leg Jump	3	8			
	Drop Single Jump	3	8			
	Double Leg Drop Jump	3	8			
	Up And Down Jump	3	8			
	Tuck Jump	3	8			
	Explosive Start Throw	3	8			
	Side Throw	3	8			

	Hurdles Jump					
	Front Bound	3	8			

Saturday	Side Bounding	3	8	2min	2min	4min.
	Skip Bounding	3	8			
	Lateral Single Leg Jump With Bounding	3	8			
	Swimming Jump Under The Hurdles	3	8			
	Both Leg Jump Over The Hurdles	3	8			
	Explosive Start Throw	3	8			
	Side Throw	3	8			

Week 6

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Cone/Ladder			2min	2min	4min.
	Side To Side Ankle Hop	3	8			
	Front Cone Hop	3	8			
	Lateral Jump Over Barrier	3	8			
	Bounding Over Ladder	3	8			
	Back Jump Over The Cone	3	8			
	Hop Over The Cone	3	8			
	Ladder Push Up	3	8			
	Ladder Walk	3	8			

Thursday	Surface : Sand			2min	2min	4min.
	Sbj Single Jump	3	8			
	Sbj Double	3	8			
	Sbj Tripple	3	8			
	Sbj Hop Single	3	8			
	Sbj Hop Double	3	8			
	Sbj Hop Triple	3	8			
	Over Head Throw	3	8			
	Over Back Toss	3	8			

	Hurdles Jump					

Saturday	Front Bound	3	8	2min	2min	4min.
	Side Bounding	3	8			
	Skip Bounding	3	8			
	Lateral Single Leg Jump With Bounding	3	8			
	Swimming Jump Under The Hurdles	3	8			
	Both Leg Jump Over The Hurdles	3	8			
	Explosive Start Throw	3	8			
	Side Throw	3	8			

Week 7

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Ground			2min	2min	4min.
	Vertical Depth Jump	3	8			
	Pin Jump	3	8			
	Squat Jump	3	8			
	Lateral Jump	3	8			
	Leg Bound	3	8			
	Back Jump	3	8			
	Over Head Throw	3	8			
	Over Back Toss	3	8			

Thursday	Box			2min	2min	4min.
	Single Leg Jump	3	8			
	Double Leg Jump	3	8			
	Drop Single Jump	3	8			
	Double Leg Drop Jump	3	8			
	Up And Down Jump	3	8			
	Tuck Jump	3	8			
	Explosive Start Throw	3	8			

	Side Throw	3	8			

Saturday	Step-Up			2min	2min	4min.
	Plyometric Push-Up	3	8			
	Split Jump	3	8			
	Scoop Hopping	3	8			
	Step Up-1	3	8			
	Step Up-2	3	8			
	Step Up-3	3	8			

Week 8

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Cone/Ladder			2min	2min	4min.
	Side To Side Ankle Hop	3	8			
	Front Cone Hop	3	8			
	Lateral Jump Over Barrier	3	8			
	Bounding Over Ladder	3	8			
	Back Jump Over The Cone	3	8			
	Hop Over The Cone	3	8			
	Ladder Push Up	3	8			
	Ladder Walk	3	8			

Thursday	Sand			2min	2min	4min.
	Sbj Single Jump	3	8			
	Sbj Double	3	8			
	Sbj Tripple	3	8			
	Sbj Hop Single	3	8			
	Sbj Hop Double	3	8			
	Sbj Hop Triple	3	8			
	Over Head Throw	3	8			
	Over Back Toss	3	8			

	Hurdles Jump					
	Front Bound	3	8			
	Side Bounding	3	8			

Saturday	Skip Bounding	3	8	2min	2min	4min.
	Lateral Single Leg Jump (Bounding)	3	8			
	Swimming Jump Under The Hurdles	3	8			
	Both Leg Jump Over The Hurdles	3	8			
	Explosive Start Throw	3	8			
	Side Throw	3	8			

Week 9

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Ground			2min	2min	4min.
	Vertical Depth Jump	3	6			
	Pin Jump	3	6			
	Squat Jump	3	6			
	Lateral Jump	3	6			
	Leg Bound	3	6			
	Back Jump	3	6			
	Over Head Throw	3	6			
	Over Back Toss	3	6			
Thursday	Box			2min	min	4min.
	Single Leg Jump	3	6			
	Double Leg Jump	3	6			
	Drop Single Jump	3	6			
	Double Leg Drop Jump	3	6			
	Up And Down Jump	3	6			
	Tuck Jump	3	6			
	Explosive Start Throw	3	6			
	Side Throw	3	6			
Saturday	Step-Up			2min	2min	4min.
	Plyometric Push-Up	3	6			
	Split Jump	3	6			
	Scoop Hopping	3	6			
	Step Up-1	3	6			

	Step Up-2	3	6			
	Step Up-3	3	6			
	Step Up Clap Push Up	3	6			
	Wheel Barrow Walk Push Jump	3	6			

Week 10

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Cone/Ladder			1/5min	2min	3/5min.
	Side To Side Ankle Hop	3	6			
	Front Cone Hop	3	6			
	Lateral Jump Over Barrier	3	6			
	Bounding Over Ladder	3	6			
	Back Jump Over The Cone	3	6			
	Hop Over The Cone	3	6			
	Ladder Push Up	3	6			
	Ladder Walk	3	6			
Thursday	Sand			1/5min	2min	3/5min.
	Sbj Single Jump	3	6			
	Sbj Double	3	6			
	Sbj Tripple	3	6			
	Sbj Hop Single	3	6			
	Sbj Hop Double	3	6			
	Sbj Hop Triple	3	6			
	Over Head Throw	3	6			
	Over Back Toss	3	6			
	Hurdles Jump					
	Front Bound	3	6			
	Side Bounding	3	6			
	Skip Bounding	3	6			
	Lateral Single Leg Jump With Bounding	3	6			
	Swimming Jump Under The Hurdles	3	6			

Saturday	Both Leg Jump Over The Hurdles	3	6	1/5min	2min	3/5min.
	Explosive Start Throw	3	6			
	Side Throw	3	6			

Week 11

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Cone/Ladder			1min	2min	3min.
	Side To Side Ankle Hop	3	5			
	Front Cone Hop	3	5			
	Lateral Jump Over Barrier	3	5			
	Bounding Over Ladder	3	5			
	Back Jump Over The Cone	3	5			
	Hop Over The Cone	3	5			
	Ladder Push Up	3	5			
	Ladder Walk	3	5			
Thursday	Sand			1min	2min	3min.
	Sbj Single Jump	3	5			
	Sbj Double	3	5			
	Sbj Tripple	3	5			
	Sbj Hop Single	3	5			
	Sbj Hop Double	3	5			
	Sbj Hop Triple	3	5			
	Over Head Throw	3	5			
	Over Back Toss	3	5			
Saturday	Hurdles Jump			1min	2min	3min.
	Front Bound	3	5			
	Side Bounding	3	5			
	Skip Bounding	3	5			
	Lateral Single Leg Jump With Bounding	3	5			
	Swimming Jump Under The Hurdles	3	5			
	Both Leg Jump Over The Hurdles	3	5			

	Explosive Start Throw	3	5			
	Side Throw	3	5			

Week 12

Days	Plyometric Drills	Sets	Reps	Duration	Recovery	Total duration
Tuesday	Cone/Ladder			1min	2min	3min.
	Side To Side Ankle Hop	3	5			
	Front Cone Hop	3	5			
	Lateral Jump Over Barrier	3	5			
	Bounding Over Ladder	3	5			
	Back Jump Over The Cone	3	5			
	Hop Over The Cone	3	5			
	Ladder Push Up	3	5			
	Ladder Walk	3	5			
Thursday	Sand			1min	2min	3min.
	Sbj Single Jump	3	5			
	Sbj Double	3	5			
	Sbj Tripple	3	5			
	Sbj Hop Single	3	5			
	Sbj Hop Double	3	5			
	Sbj Hop Triple	3	5			
	Over Head Throw	3	5			
	Over Back Toss	3	5			
Saturday	Hurdles Jump			1min	2min	3min.
	Front Bound	3	5			
	Side Bounding	3	5			
	Skip Bounding	3	5			
	Lateral Single Leg Jump With Bounding	3	5			
	Swimming Jump Under The Hurdles	3	5			
	Both Leg Jump Over The Hurdles	3	5			
	Explosive Start Throw	3	5			
	Side Throw	3	5			

3.3.2 Dependents Variables

In sprinting, where maximum strength and speed are paramount, an athlete's performance is influenced by key motor skills including speed, muscular endurance explosive strength, reaction time, flexibility, and skill performance. Speed influences sprint time, whereas power and muscle strength offer explosive force for rapid starts and acceleration. Reaction time influences an athlete's ability to Balance is essential for maintaining ideal running form and responding quickly to starting signals. Flexibility improves stride mechanics, whereas muscular endurance promotes prolonged performance. Skill performance encompasses the efficiency of sprinting techniques, integrating all these factors into overall effectiveness. By focusing on these variables, plyometric training can be tailored to enhance specific aspects of sprinting, thereby improving overall athletic performance.

Dependent Variables test table

DEPENDENT VARIABLES	TEST	TOOLS	UNIT OF MEASUREMENT
Speed	30meter, flying sprint	Stopwatch	Meter/second
Explosives Strength	Standing Vertical Jump/ Sargent's Test	Measuring tape	meters, Centimeters
Reaction time	Response	Stop watch, Gun	seconds
Flexibility	Sit and reach	Flexo- meter	Centimeters
Muscular endurance	Bent knee Sit ups	Stop watch	Max number,as per time
Skills performance	100m run	Stop watch	Seconds

3.3.2.1 Speed

Test: 30 meters flying sprint

The time taken by an athlete to run 30m is considered to measure the speed. The athletes were made to run a distance of 50 meters and the time taken to run the 20m to 50m mark was considered. The 0m to 20m distance was not considered to eliminate the effect of start and acceleration.

Figure 3.1, 30m run

Tools/Infrastructure: Track with 0, 20m, 50m markings. Hand held stop watch

Test Parameters: Time taken to run 30 meters Calculation: $s = dt$ where s = speed in ms-1 d = distance (30 meters) t = time taken by the athlete to run the distance Unit of Measurement: meters per second (ms-1)

3.3.2.2 Explosive Strength

Test: Sargent Jump Test

In the Sargent Jump Test, the athlete faces a smooth wall, feet flat and toes touching. They reach as high as they can with one hand to mark the wall with chalk or chalk dust. After marking, the athlete jumps as high as possible from this position, leaving another mark at the height of the jump. The vertical jump score is computed as the difference between the two marks, which are measured in inches or centimeters.

Figure 3.2 Sargent/ Vertical Jump Test

Tools/Infrastructure: Wall, marking chalk, Measuring tape

Test Parameters: Jump Height, Body mass

3.3.2.3 Reaction Time

Test: Response to gun shot

The time difference between the gun shot and the first step of an athlete off the starting blocks is measured to find the response time

Figure 3.3 Measuring Reaction Time

Tools/Infrastructure: Stop Watch, sounding gun, starting blocks

Test Parameter: Time taken to take the first step

3.3.2.4 Flexibility

Test: Sit and reach.

The individual was requested to take off his shoes and place his feet against the testing box while sitting on the floor with straight legs. The patient was then instructed to place both hands on top of the middle fingers of their feet. The patient was directed to bend forward and place his hands over the measuring scale sitting on top of the box, with the 10-inch mark aligned with the front edge of the testing box. The participant was then instructed to glide his hands as far along the measuring scale as possible without bouncing, holding the furthest position for at least five seconds.

Figure:3.4 Sit and Reach test

Tools/Infrastructure: measuring scale

Test Parameters: Distance of reach Unit of Measurement: cm

3.3.2.5 Muscular Endurance

Test: Bent knees sit up

The individual is requested to lay on their back, knees bent, feet on the ground, heels no more than 12 inches from the buttocks. The knee angle should be less than 90 0 degrees. The individual is advised to lay his or her hand on the back of the neck, fingers clasped, elbows solidly on the ground. A buddy holds the subject's feet to ensure that they do not leave the surface while bringing the head and elbows forward to tighten the abdominal muscles and curling up to connect the elbows to the knees.The complete method above equals one bent knee sit-up. The individual is instructed to return to the beginning posture with his elbows on the surface before sitting up again. Before administering the exam, the tester delivers the demonstration to all the people being tested. The timer responds to the beginning indications ready, go! The timer starts the stopwatch when the word 'go' is said, and the subject begins the Bent knees sit-up performance as swiftly as possible with his best efforts.The tester begins counting the

number of bent-knee sit-ups accomplished. After 60 seconds, the timer signals the subject to stop, and the tester records the number of accurately executed bent knee sit-ups accomplished by the subject in 60 seconds. This gives the test score. Only one trial is provided unless the tester considers the individual did not have a fair chance to perform. The subject is not permitted to rest between Bent Knee Sit-ups during the performance. No improper sit-up is counted if the individual makes one of the following faults.

GPS Map Camera
Mumbai, MH, India
Vidyalankar College Marg, Wadala East,
Mumbai, 400037, MH, India
Lat 19.020506, Long 72.870553
07/01/2023 12:35 GMT+05:30
Note : Captured by GPS Map Camera

Figure 3.5 Bent Knee Sit Up

Tools/Infrastructure: Stopwatch, counter

Test Parameters: Number of bent knees sit-ups in one minute

3.2.1.6 Skill performance

Test: 100m sprint

Process: The athlete takes position on the starting block behind the mark. The gun shot was sounded and the time taken by the athlete to run the distance of 100m was noted.

Figure 3.6,100m run

3.4 Cool Down Exercise

Static exercises are more effective as cool down exercises than dynamic exercises.

Cool Down Exercise(15min)	Minutes	Distance
sit and holding toes fold one leg and sit and holding toes spread leg and hold toes Butter fly leg and hold	5 to 10sec	on the spot

Chapter 4

Analysis of data and Results

4.1 Introduction

This chapter presents the results of the study conducted to examine the effect of plyometric training on selected motor fitness components of 100-meter sprinters in Mumbai. The Samples were divided into control and experimental groups. Data collected from both groups before and after the training program were systematically tabulated, analyzed, and interpreted to determine the significance of changes in performance. The results are presented under appropriate headings, with statistical treatment, tables, representations for clarity and comparison between the groups.

.4.2 Analysis of data

4.2.1 Speed

Question 1: In Control Group, is there a significant change in the time taken to complete 30 meter run?

Let, H0: $\mu pre - \mu post = 0$

Ha: $\mu pre - \mu post \neq 0$

where, μpre: time taken to complete 30m before the training.

$\mu post$: time taken to complete 30m after the training.

Table 4.1 Paired z test: Comparison of Time taken to run 30m pre training v/s post training in Control Group

	speed 30t_pre_c	*speed 30t_post_c*
Mean	4.8136	4.7776
Known Variance	0.388396324	0.391264432
Observations	75	75
Hypothesized Mean Difference	0	
Z	0.353085835	
P(Z<=z) one-tail	0.362012046	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.724024092	
z Critical two-tail	1.959963985	

Result and Analysis:

As the p-value (0.724) is greater than 0.05, the researcher failed to reject the null hypothesis. Hence, there is no enough information to conclude that there is a statistically significant difference between the means of Samples 1 and 2. This is highlighted by almost similar means of (4.8136 vs.4.7776).

Question 2: In Experimental Group, is there a significant change in the time taken to complete 30-meter run?

Let, H0: $\mu pre - \mu post = 0$

Ha: $\mu pre - \mu post \neq 0$

where, μpre: time taken to complete 30m before the training μpost: time taken to complete 30m after the training

Table 4. 2 Paired z test: Comparison of Time taken to run 30m pre training v/s post training in Experimental Group

	speed 30t_pre_e	*speed 30t_post_e*
Mean	4.8136	4.4696
Known Variance	0.388396324	0.422403892
Observations	75	75
Hypothesized Mean Difference	0	
Z	3.308507675	
P(Z<=z) one-tail	0.000468973	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.000937946	
z Critical two-tail	1.959963985	

where,

speed30mt_pre_e = Time taken by Experimental Group to complete 30m run before the training, speed30mt_post_e = Time taken by Experimental Group to complete 30m run after the training Based on the Z-test

results: As the p-value (0.0009) is less than 0.05, the researcher rejected the null hypothesis that there is no difference between the means of “speed 30t_pre_e” and “speed 30t_post_e”. • There is strong evidence to suggest that there is a statistically significant difference between the means of the two groups. • The direction of the difference is indicated by the means: “speed 30t_pre_e” has a higher mean than “speed 30t_post_e”. • Both one-tailed and two-tailed p-values indicate a highly significant difference.

4.2.2 Explosive Strength

Test: Sargent’s Vertical Jump

Question 3: In Control Group, is there a significant change in explosive strength in legs measured using Sayer formula, before and after the training?

Let, H0: $\mu pre - \mu post = 0$

Ha: $\mu pre - \mu post \neq 0$

where, μpre: explosive strength before the training μpost: explosive strength after the

training

Table 4. 3 Paired z test: Comparison of Vertical Jump pre training v/s post training in Control Group.

		vj_per_c	vj_post_c
Mean		53.29333333	53.85333333
Known Variance		92.91279279	94.74846847
Observations		75	75
Hypothesized Difference	Mean	0	
Z		-0.35402289	
P(Z<=z) one-tail		0.361660864	
z Critical one-tail		1.644853627	
P(Z<=z) two-tail		0.723321729	
z Critical two-tail		1.959963985	

where,

Result and Analysis:

As the p-value (0.723) is greater than 0.05, the researcher failed to reject the null hypothesis. Hence, there is no enough information to conclude that there is a statistically significant difference between the means of Samples 1 and 2. This is highlighted by almost similar means of (53.293 vs.53.853).

Question 4: In Experimental Group, is there a significant change in the explosive strength in legs measured using Sayer formula, before and after the training?

Let, H0: μpre - μpost = 0

Ha: μpre - μpost ≠ 0

where, μpre: explosive strength before the training μpost: explosive strength after the training

Table 4. 4: Paired z test: Comparison of Vertical Jump pre training v/s post training in Experimental Group

	vj_per_e	vj_c_post_e
Mean	55.14864865	58.64864865
Known Variance	71.8209009	57.81513514
Observations	74	74
Hypothesized Mean Difference	0	
Z	-2.644362762	
P(Z<=z) one-tail	0.004092244	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.008184489	
z Critical two-tail	1.959963985	

where,

Result and Analysis:

As the p-value (0.0081) is less than 0.05, the researcher rejected the null hypothesis that there is no difference between the means of Group 1 and Group 2.There is strong evidence to suggest that there is a statistically significant difference between the means of the two groups.The direction of the difference is indicated by the means: "Vertical Jump_pre_e" has a higher mean than " Vertical Jump _post_e". • Both one-tailed and two-tailed p-values indicate a highly significant difference.Both one-tailed and two-tailed p-values indicate that the difference is highly significant. Therefore, we conclude that Group 2 is significantly higher than Group 1 based on the results of the z-test.

4.2.3 Reaction Time:

Test: Time taken to take the first step off the block.

Question 5: In Control Group, is there a significant change in the reaction time of first step off the starting block?

Let, H0: μpre - μpost = 0

Ha: μpre - μpost ≠ 0

where, μpre: reaction time before the training μpost: reaction time after the training

Table 4.5 Paired z test: Comparison of Reaction Time pre training v/s post training in Control Group.

	rt Pre -C	*rt post -C*
Mean	0.10672	0.107853
Known Variance	0.003242	0.003408
Observations	75	75
Hypothesized Mean Difference	0	
Z	-0.12035	
P(Z<=z) one-tail	0.452101	
z Critical one-tail	1.644854	
P(Z<=z) two-tail	0.904202	
z Critical two-tail	1.959964	

where,

rt_pre_c = Reaction Time before training, in Control group rt_post_c = Reaction Time after training, in Control group

Result and Analysis:

As the p-value (0.904) is greater than 0.05, the researcher failed to reject the null hypothesis. Hence, there is no enough information to conclude that there is a statistically significant difference between the means of Samples 1 and 2. This is highlighted by almost similar means of (0.10672 vs.0.1078).

Question 6: In Experimental Group, is there a significant change in the reaction time of first step off the starting block?

Let, H0: μpre - μpost = 0

Ha: μpre - μpost ≠ 0

where, μpre: reaction time before the training μpost: reaction time after the training

Table 4.6 Paired z test: Comparison of Reaction Time pre training v/s post training in Experimental Group

	rt Pre -e	*rt post -e*
Mean	0.115041	0.109527
Known Variance	0.003487	0.003692
Observations	74	74
Hypothesized Mean Difference	5	
Z	-507.082	
P(Z<=z) one-tail	0.0000	
z Critical one-tail	1.644854	
P(Z<=z) two-tail	0.0000	
z Critical two-tail	1.959964	

where,

rt_pre_e = Reaction Time before training, in Experimental group rt_post_e = Reaction Time after training, in Experimental group Result and Analysis:

Based on the data, we reject the null hypothesis that the two samples' means are equal. The findings strongly indicate that Sample 1 has a much higher mean than Sample 2.

4.3.4 Flexibility:

Test: Sit and reach

Question 7: In Control Group, is there a significant change in flexibility?

Let, H0: μpre - μpost = 0

Ha: μpre - μpost ≠ 0

were, μpre: flexibility before the training μpost: flexibility after the training

Table 4.7 Paired z test: Comparison of Flexibility pre training v/s post training in Control Group.

	flex_pre_c	flex_post_c
Mean	11.74666667	12.06666667
Known Variance	3.218738739	5.603603604
Observations	75	75
Hypothesized Mean Difference	0	
Z	-0.933015067	
P(Z<=z) one-tail	0.175406095	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.350812189	
z Critical two-tail	1.959963985	

where,

flex_pre_c = Flexibility before training, in Control group flex_post_c = Flexibility after training, in Control group

Result and Analysis:

As the p-value (0.3508) is greater than 0.05, the researcher failed to reject the null hypothesis. Hence, there is no enough information to conclude that there is a statistically significant difference between the means of Samples 1 and 2. This is highlighted by almost similar means of (11.7466 vs.12.6666).

Question 8: In Experimental Group, is there a significant change in flexibility?

Let, H0: μpre - μpost = 0 Ha: μpre - μpost ≠ 0

were, μpre: flexibility before the training μpost: flexibility after the training

Table 4.8 Paired z test: Comparison of Flexibility pre training v/s post training in Experimental Group.

where,

	Flex SAR_pre_e	*Flex SAR_post_e*
Mean	12.89333333	14.38666667
Known Variance	1.150630631	1.564684685
Observations	75	75
Hypothesized Mean Difference	0	
Z	-7.848330013	
P(Z<=z) one-tail	0.0000	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.0000	
z Critical two-tail	1.959963985	

flex_pre_e = Flexibility (SAR)before training, in Experimental group flex_post_e = Flexibility (SAR) after training, in Experimental group

Result and Analysis:

As the p-value (0.0000) is less than 0.05, the researcher rejected the null hypothesis that the two samples' means are equal. The findings clearly suggest that Sample 1 has a much lower mean than Sample 2.

4.3.5 Muscular Endurance

Test: Bent knees sit ups

Question 9: In Control Group, is there a significant change in muscular endurance?

Let, H0: μpre - μpost = 0 Ha: μpre - μpost ≠ 0

were, μpre: muscular endurance before the training μpost: muscular endurance after the training

Table 4. 9 Paired z test: Comparison of Muscular Endurance pre training v/s post training in Control Group.

	endu_per_c	endu post_c
	22	23
Mean	26.58108108	26.6081081
Known Variance	24.73945946	24.6281081
Observations	74	74
Hypothesized Mean Difference	0	
Z	-0.033089734	
P(Z<=z) one-tail	0.486801515	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.97360303	
z Critical two-tail	1.959963985	

where,

endu_pre_c = muscular endurance before training, in Control group endu_post_c = muscular endurance after training, in Control group

Result and Analysis:

Based on our findings, as the p-value (0.9736) is greater than 0.05, the researcher failed to reject the null hypothesis. Hence, there is no enough information to conclude that there is a statistically significant difference between the means of Samples 1 and 2. This is highlighted by almost similar means of (26.5810 vs.26.6081).

Question 10: In Experimental Group, is there a significant change in muscular endurance?

Let, H0: μpre - μpost = 0

Ha: μpre - μpost ≠ 0

were, μpre: muscular endurance before the training μpost: muscular endurance after the training

Table 4.10 Paired z test: Comparison of Muscular Endurance pre training v/s post training in Experimental Group

	endu_per_e	endu_post_e
Mean	27.08	32.82666667
Known Variance	28.50702703	37.22630631
Observations	75	75
Hypothesized Mean		
Difference	0	
Z	-6.13838057	
P(Z<=z) one-tail	0.000	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.000	
z Critical two-tail	1.959963985	

where,

endu_pre_e = muscular endurance before training, in Experimental group endu_post_e = muscular endurance after training, in Experimental group Result and Analysis:

Based on our findings, As the p-value (0.0000) is less than 0.05, the researcher rejected the null hypothesis that the means of the two samples are equal. The findings strongly indicate that Sample 1 has a much lower mean than Sample 2

4.3.6 Skill performance

Test: 100m sprint

Question 11: In Control Group, is there a significant change in the the skill performance in 100m?

Let, H0: $\mu pre - \mu post = 0$

Ha: $\mu pre - \mu post \neq 0$

where, µpre: time for 100m run before the training µpost: time for 100m run after the training

Table 4. 11 Paired z test: Comparison of Skill Performance(100m) pre training v/s post training in Control Group

	Skill(100m)_pre_c	*Skill(100m)post_c*
Mean	13.66266667	13.58666667
Known Variance	2.302371171	2.288198198
Observations	75	75
Hypothesized Mean Difference	0	
Z	0.307192739	
P(Z<=z) one-tail	0.379348336	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.758696672	
z Critical two-tail	1.959963985	

where,

skill_pre_c = Time taken to run 100m before training, in Control group skill_post_c = Time taken to run 100m after training, in Control group Result and analysis:

As the p-value (0.7586) is greater than 0.05, the researcher failed to reject the null hypothesis. Hence, there is no enough information to conclude that there is a statistically significant difference between the means of Samples 1 and 2. This is highlighted by almost similar means of (13.6626 vs.13.5866).

Question 12: In Experimental Group, is there a significant change in the skill performance in 100m?

Let, H0: µpre - µpost = 0

Ha: µpre - µpost ≠ 0

where, µpre: reaction time before the training µpost: reaction time after the training

Table 4. 12 Paired z test: Comparison of Skill Performance pre training v/s post training in Experimental Group.

	Skill(100m)_pre_e	*Skill(100m)post_e*
Mean	13.82567568	11.7377027
Known Variance	1.908187387	0.285495928
Observations	74	74
Hypothesized Mean Difference	0	
Z	12.12701086	
P(Z<=z) one-tail	0.000	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.000	
z Critical two-tail	1.959963985	

where,

skill_pre_e = Time taken to run 100m before training, in Experimental group skill_post_e = Time taken to run 100m after training, in Experimental group

Result and Analysis:

Based on our findings, as the p-value (0.0000) is less than 0.05, the researcher rejected the null hypothesis that the means of the two samples are equal. The findings strongly indicate that Sample 2 has a much lower mean than Sample 1.

4.3 Result

Summary of Questions

Question No	Question	Answer
1	In Control Group, is there a significant change in the time taken to complete 30-meter run?	No
2	In Experimental Group, is there significant change in the time taken to complete 30-meter run?	Yes.
3	In Control Group, is there a significant change in explosive Strength in legs measured using Sayers formula, before and	No

	after the training?	
4	In Experimental Group, is there a significant change in explosive Strength in legs measured using Sayers formula, before and after the training?	Yes
5	Is there a substantial difference in reaction time in the Control Group's initial stride off the starting block?	No
6	Is there a substantial difference in reaction time in the Experimental Group's initial stride off the starting block?	Yes
7	In Control Group, is there a significant change in flexibility?	No
8	In Experimental Group, is there significant change in flexibility?	Yes.
9	In Control Group, is there a significant change in muscular endurance?	No
10	In Experimental Group, is there a significant change in muscular endurance?	Yes.
11	In Control Group, is there a significant change in the skill performance in 100m?	No
12	In Experimental Group, is there a significant change in the skill performance in 100m?	Yes

Chapter 5

Summary Conclusion and Recommendation

5.1 Summary

Sprinting events are very popular in athletics. These events are short but very fast, testing the athlete's physical limits. There is no time to correct mistakes, so athletes must perform perfectly. This makes proper and complete coaching very important. Plyometric exercises help muscles produce more power quickly by using a natural stretch-and-shorten movement. These exercises are good for sprinters, but because they involve strong forces, there is a risk of injury. It is also important to know the athlete's current strengths and weaknesses to plan the right training. This study, titled "Effect of Plyometric Training on Selected Motor Fitness Components and Skill Performance of College Male Sprinters," aimed to see how plyometric training affects speed, power, muscular endurance, balance, reaction time, and sprinting skills of college sprinters. The study also involved looking at different plyometric drills and choosing the best ones for the experiment.

Summary of changes in Motor Fitness Components.

Component	Was here significant change in Control Group?	Was there significan change in Experimental Group?	Which group had more improvement?
Speed	No	Yes	Experimental
Explosive Strength	No	Yes	Experimental
Reaction Time	No	Yes	Experimental
Flexibility	No	Yes	Experimental
Muscular Endurance	No	Yes	Experimental
Skill performance	No	Yes	Experimental

5.2 Conclusion

Athletes were tested before and after the training period and the readings were analyzed. Athletes in the Experimental Group, who had been administered plyometric training in addition to the regular athletics training administered to the Control Group, showed significant improvements in all the measured motor fitness components. While concluding it may be concluded that

- There was significant improvement in speed of male 100m sprinters due to plyometric training.
- There was significant improvement in explosive strength of male 100m sprinters due to plyometric training.
- There was significant improvement in reaction time of male 100m sprinters due to plyometric training.
- There was significant improvement in flexibility of male sprinters due to plyometric training.
- There was significant improvement in muscular endurance of male 100m sprinters due to plyometric training.
- There was significant improvement in Skills Performance of male 100m sprinters due to plyometric training.

5.1 Recommendation

On the basis of the studied literature and the results of this study, coaches and athletes can consider the following recommendations.

- Plyometrics can be included in the training programmer of sprinters to improve their performance.

- Coaches must ensure that the athletes are physically fit and their muscles are ready to endure the shock treatment that the stretch shortening cycle of the plyometric exercise puts on the muscles.

- The intensity and the hardness of the landing surface should be increased gradually to ensure best results and avoid injuries.

- It is very important to ensure correct form during the exercise for maximum gains and minimum injuries.

- Single leg plyometric exercises and movement in the horizontal direction, emulate the way the athletes' body will move during the race. Hence, it is better to include exercises that are similar to the movements of an athlete in a race.

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